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Effect of breed on response to foot rot treatment in mature sheep and lambs

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Abstract

Our objective was to determine whether breed differences existed in response to exposure and treatment of virulent foot rot. Dorset (DS), 1/2 Dorper (DX), 3/4 or greater Dorper (DO), Gulf Coast Native (GC), Katahdin (KA), and St. Croix (SC) mature sheep and lambs were exposed to virulent foot rot in spring 2003. Treatment for foot rot was initiated in 132 lambs and 262 mature sheep in late July. There were eight pasture groups treated, two of which were minimally exposed to foot rot. Treatment included hoof paring, foot bathing with 10% zinc sulfate with surfactant, allowing the zinc sulfate to dry on the foot and moving to a small paddock that had not been exposed to small ruminants for more than 14 d. Foot bathing was repeated every 7 d for a maximum of five treatments. Animals that had not responded (odor or any indication of persistent infection) by then were culled from the flock. As an indication of severity of foot rot for each animal, the number of areas on the foot (interdigital and two digits for each foot), a foot score (0 = no infection found; 1 = infection of digits only; 2 = infection of interdigital area and could include digits), and presence of characteristic odor was recorded. Least squares means for number of areas infected were greater for mature than growing sheep (2.07 ± 0.16 versus 0.88 ± 0.31; $P < 0.001$), for highly than minimally exposed groups (2.89 ± 0.17 versus 0.05 ± 0.29; $P < 0.001$), and DX compared with other breed types ($P < 0.03$). Percentage of sheep with odor was similar between age groups, was greater in the highly exposed groups (11.4 ± 1.9 versus 2.1 ± 3.4; $P < 0.02$), and greater in DO compared with DS, KA, and SC breeds ($P < 0.001$). Foot score was similar among breeds and greater in the highly exposed groups (age by group, $P < 0.05$). Percentage of sheep culled for failure to respond to foot bath treatment was greater for the highly than minimally exposed group (22.9 ± 2.3 versus 0.0 ± 3.9; $P < 0.001$) and greater for mature sheep compared with lambs ($P < 0.001$) and similar among breeds. In November, four ewes in a large group and two lambs in a small group were determined to have foot rot and were immediately culled. The two groups containing these ewes were re-treated for 2 weeks and were determined to be free of foot rot (no further signs of lameness). Response to foot rot eradication appeared to be similar among breeds examined.
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Keywords: Foot rot; Hair breeds; Sheep

1. Introduction

Virulent foot rot is a highly contagious disease that affects all aspects of production of small ruminants. Virulent foot rot involves the interaction between the obligate anaerobic bacteria, *Dichelobacter nodosus* and *Fusobacterium necrophorum*, the former necessary for

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transmission and which can be controlled and the latter which causes much of the inflammation and lameness (Egerton et al., 1969; Roberts and Egerton, 1969; ASI, 2002). Contamination occurs by the spread of *D. nodosus* from infected sheep to soil or environment to uninfected sheep and survival of this organism does not last more than 14 d in the soil.

Treatment programs have included vaccines, which provide some protection for approximately a 12-week period or less (Lambell, 1986; Schwartzkoff et al., 1993; Hunt et al., 1994), antibiotics, which provide temporary relief, foot bathing using zinc sulfate with a surfactant by walking or soaking for up to 60 min with and without paring (reviewed by Abbot and Lewis, 2005). Paring provides exposure of infected tissues to zinc sulfate and may improve the efficacy of a walk-through topical treatment (Skerman et al., 1983; Bagley et al., 1987).

There have been studies demonstrating that Merinos are more susceptible to foot rot infection than Romney, Dorset (DS), or Border Leicester breeds of sheep (Skerman et al., 1982; Emery et al., 1984; Stewart et al., 1985). Resistance in individual animals within a breed has also been observed (Parker et al., 1985). The objective of this study was to determine whether breed differences existed in response to exposure and treatment of virulent foot rot.

2. Materials and methods

All experimental procedures were reviewed and approved by the USDA, Agricultural Research Service Animal Care and Use Committee in accordance to National Institute of Health guidelines for Care and Use of Laboratory Animals. Pain and stress to sheep were minimized throughout the experiment.

The populations of sheep at this research site, USDA, ARS, Booneville, AR, appear to have characteristics typical of their breed types, but because of the relatively small numbers may not be representative of these breeds found throughout the U.S. The 3/4 or greater Dorper (DO) sheep used for these studies were derived from purebred black or white rams bred to St. Croix (SC) ewes from this ARS station or Romanov ewes from this station and a private farm and upgraded to 3/4 or greater percentage DO. Five DO sires, in a single-sire mating, were used to generate crossbred replacement lambs in 1999 through 2001 breeding. The Katahdin (KA) ewes were derived from two farms (three genetic lines from one farm and commercial ewes from a second farm) and the rams from an additional two farms and within the ARS flock. Since 2001, all ewe lambs were raised at the research Center. The SC flock has been at the Booneville site since 1987, and replacement rams have been derived from within the flock and three additional farms. Replacement ewe lambs were derived from within the flock.

Sheep grazed tall fescue (*Festuca arundinacea*) or bermudagrass (*Cynodon dactylon*) overseeded with rye (*Secale cereale*) and had continuous access to trace mineralized salt (Land O'Lakes Sheep and Goat Mineral, Shoreview, MN) and water. Lambs and lactating ewes were supplemented with corn/soybean (16% CP with added lasolocid; up to 500 g/d for growing lambs and up to 1 kg/d for lactating ewes). Stocking rate of all pastures was approximately 5.5 ewes or lambs per hectare.

Virulent or contagious foot rot had not been observed in this flock before 2003. Presumably virulent foot rot was introduced to this flock from a small group of sheep that were acquired in spring 2003, because within 4 weeks after co-mingling several of the resident sheep became lame. Treatment for foot rot was initiated in 132 lambs and 262 mature sheep in late July during a dry summer (3.3 mm total rainfall in July and August). Breeds were 1/2 Dorper (DX), 3/4 or greater Dorper, Dorset (DS), Gulf Coast Native (GC), Katahdin, and St. Croix (Table 1). There were eight pasture groups treated, two of which had minimal exposure to the infected animals. In these pastures, contamination occurred through human foot traffic and introduction of an infected teaser ram.

The treatment regimen followed was paring of the hoof to completely expose infected area, foot bathing with 10% zinc sulfate with surfactant (approximately 1.2% (v/v) dish soap; 4.8 m foot bath) for approximately 10–20 s, drying on disinfected concrete pens for 24 h and removal to clean area that had been free of sheep for more than 14 d. Location of infection on foot (digit or interdigital; up to 12 areas could be infected) was noted by a single observer along with presence of odor

Table 1
Groups of 1/2 or 3/4 Dorper (DO), Dorset (DS), Gulf Coast Native (GC), Katahdin (KA), and St. Croix (SC) sheep that were treated for foot rot in late July

Location	Number	Age	Breeds
1 (Tall fescue)	52	Mature ewes	DO, DS, GC
2 (Tall fescue)[a]	135	Mature ewes	DO, GC, KA, SC
3 (Bermudagrass)	42	120 d lambs	DO, KA, SC
4 (Tall fescue)	12	Mature ewes	DO, GC, KA, SC
5 (Mixed grasses)	19	Mature rams	DO, DS, GC, KA, SC
6 (Tall fescue)	50	240 d lambs	DO, KA
7 (Concrete dry lot)[a]	20	240 d lambs	DO
8 (Bermudagrass)	64	120 d lambs	DO, KA, SC

[a] Pastures or groups with minimal exposure.

characteristic of virulent foot rot. Level of infection for each animal was scored (0 = no infection found; 1 = infection of digits only; 2 = infection of interdigital area and could include digits). Infection can be defined as inflammation of the horny and laminar structures of the foot, which often included pus discharge, or the presence of lesions. Foot bathing and drying were repeated 7 d later. Fourteen days after initial treatment, all hooves were pared again to visualize clearly. Response to treatment was recorded as completely healed (no inflammation or lesions observed) or the location on foot that was still infected was recorded. Foot bathing and drying was repeated. Animals in which no lesions or inflammation was observed were moved to a clean permanent pasture and observed for lameness twice weekly. Animals that did not respond to treatment (odor or severe infection still present) were immediately culled and removed from the flock. Foot bathing and drying was repeated for an additional 2 weeks for animals in which lesions or inflammation was lessening, based on earlier recorded observations. For these animals, 28 d after initial treatment, hooves were pared to visualize remaining infection. Animals that were completely healed were removed to a clean pasture and animals in which lesions remained were immediately culled and removed from the flock. Concrete pens used for drying were always decontaminated using a solution of sodium hypochlorite (5250 ppm) and a fresh solution of zinc sulfate foot bath was made prior to use. Livestock trailers were decontaminated before moving recovered sheep. Antibiotics were not used for at least 60 d before initial treatment. Vaccine and booster (Volar; Intervet Inc., Millsboro, DE) were used on Groups 1, 2, 4, and 5 in May, which apparently offered little relief. No reduction in lameness was observed. If lame sheep were observed after final treatment, that animal was culled and the entire group re-treated.

Number of areas on foot affected by foot rot, percentage of animals with characteristic virulent foot rot odor, foot score, and percentage of animals culled were analyzed by GLM procedures of SAS (1996). Variables in the model included breed, age group (mature or lamb), pasture group (two groups were minimally exposed and six groups were highly exposed for minimal and high exposure comparisons), and significant interactions. Least squares means were separated by the PDIFF option which requests that P-values for differences of the LS-means be produced. In addition, CATMOD procedures were used for categorical data, foot score, percentage with odor and percentage culled with breed, age, and pasture group included in the model.

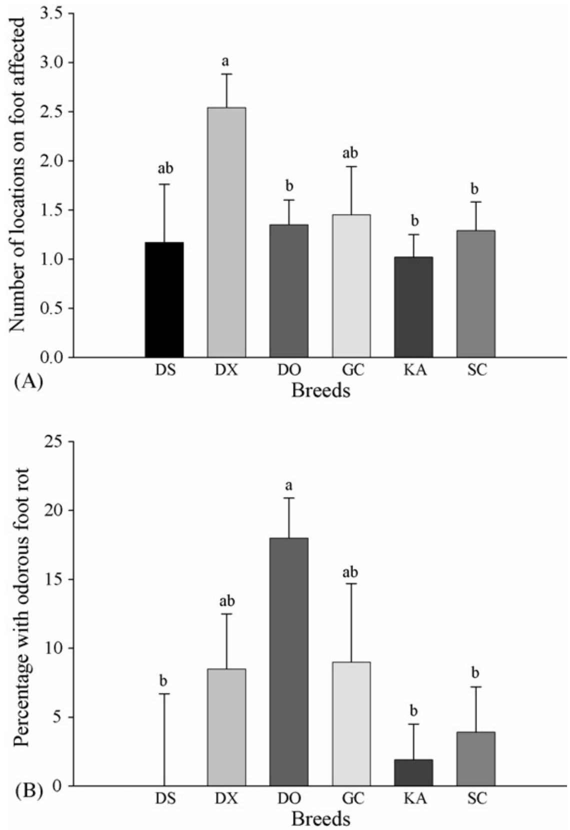

Fig. 1. Least squares means of total number of locations (up to 12) on foot affected by virulent foot rot (A) or percentage of sheep with odor characteristic of virulent foot rot (B) in Dorset (DS; $n = 21$), 1/2 Dorper (DX; $n = 50$), 3/4 or greater Dorper (DO; $n = 92$), Gulf Coast Native (GC; $n = 36$), Katahdin (KA; $n = 105$), and St. Croix (SC; $n = 79$) breeds during the initial treatment period. Bars lacking the same letters are different ($P < 0.05$).

3. Results

As an indication of severity of foot rot for each animal, the number of areas on feet that were infected and whether characteristic odor was present was recorded. Least squares means for number of locations of infection were greater for mature than growing sheep (2.07 ± 0.16 versus 0.88 ± 0.31; $P < 0.001$), for highly than minimally exposed groups (2.89 ± 0.17 versus 0.05 ± 0.29; $P < 0.001$), and DX compared with other breed types ($P < 0.03$; Fig. 1(A)). Percentage of sheep with odor was similar between age groups, was greater in the highly exposed groups (11.4 ± 1.9 versus 2.1 ± 3.4; $P < 0.02$), and greater in DO compared with DS, KA, and SC breeds ($P < 0.001$; Fig. 1(B)). Foot score was similar between lambs in both exposure groups (greater exposure: 0.97 ± 0.08; minimal exposure: 0.52 ± 0.18), but greater for mature sheep with greater exposure (greater exposure: 1.20 ± 0.06; minimal exposure: 0.31 ± 0.07; age by group interaction, $P < 0.05$). Foot score was similar among breeds. Percentage of sheep culled for failure to respond to foot bath treatment was greater for the highly than minimally exposed group (22.9 ± 2.3 versus 0.0 ± 3.9; $P < 0.001$) and greater for mature sheep compared with lambs (18.0 ± 2.2 versus 0.0 ± 4.1; $P < 0.001$) and was similar among breeds.

After the initial treatment had been completed on all groups, foot rot was discovered in mid-November 2003 in four ewes in a large group of ewes on tall fescue and two lambs in a different group. The six animals were culled. These two groups of animals were re-treated and lameness due to foot rot was not observed again until new infected animals (2 out of 46 lambs were infected) were acquired in May 2004. Treatment of these lambs failed because of extremely muddy conditions. Apparently, foot rot was tracked to other locations on the farm because foot rot was observed in the main flock. Two weeks treatment during August 2004 of approximately the same number treated in 2003 yielded only 10 culled ewes and no further outbreaks of virulent foot rot.

4. Discussion

Slight differences were observed among breed types for clinical signs of virulent foot rot. More locations on the foot were affected in DX compared with DO, KA, and SC sheep, but characteristic odor was detected on more DO than KA and SC sheep, while DS and GC were intermediate. Infection can be present without characteristic odor. However, foot score was similar among breeds. There have been no published reports on response of hair sheep to foot rot eradication programs or any evidence of resistance to foot rot, although there appears to be some perception by producers that some may be more resistant to foot rot. Overall, all breeds were susceptible, but some individuals within breeds may have been resistant or self-cured. Recovery or response rate to paring and foot bathing was similar among breeds. Parker et al. (1985) reported relative resistance in Targhee sires that could be passed to their offspring to some extent. Similarly, Raadsma et al. (1994) noted differences in resistance to foot rot in Merinos. It is important to note that conditions were very dry during the treatment program and that recovery rate is based on a per animal basis, as there were no untreated controls. During dry conditions sheep are capable of recovery without treatment (Abbot and Lewis, 2005).

There were two groups of animals that were less exposed than the other groups. These groups had fewer clinical signs of foot rot, appeared to respond to treatment more quickly (data not shown), and had a greater recovery rate. Others have shown best response to foot rot eradication when infection was detected and treated early (Casey and Martin, 1988; Hinton, 1991). There was some indication that signs of virulent foot rot were less prevalent in lambs than mature sheep and treatment response was greater. Perhaps a faster growing tissue can respond better to paring and foot bathing than mature tissue. Malecki and McCausland (1982) determined that zinc sulfate penetrated deeper in soft rather than hard horn. Typically the hooves of lambs are softer than mature sheep and zinc sulfate may have penetrated deeper in the hooves of lambs.

It is important to observe animals closely after completion of foot rot treatment for those that still may harbor the infectious organisms. Approximately 2 months post-treatment, lame animals were observed and immediately culled, followed by re-treatment of other animals within that group. The harmful bacteria may have resided in deep tissue of these lame sheep, escaping initial detection of foot rot.

Eradication of foot rot is desirable because of the potential lost production of animals suffering extreme lameness. In the current study, within days after birth, both lambs and ewes were lame, and although not specifically examined, could affect grazing behavior, milk production, and growth. In other studies, body weight and wool growth were reduced by virulent, but not benign, foot rot (Stewart et al., 1984; Marshall et al., 1991). Plasma concentrations of prolactin, cortisol, adrenaline, and noradrenaline were increased in sheep experiencing mild to severe foot rot, which persisted after sheep were no longer lame (Ley et al., 1991, 1992). These hormones are indicators of animal stress and pain. These effects of foot rot emphasize the importance of an eradication program.

5. Conclusion

In summary, differences among breed types in response to treatment of virulent foot rot were minimal. Animals that were exposed to foot rot for a shorter period of time were less likely to be culled for non-response to treatment than those exposed for a longer time. Similarly, response of lambs to treatment was more favorable than that of mature sheep. Prevention of foot rot should be exercised by avoiding purchase or acquisition of infected sheep. In the presence of foot rot, an eradication program is essential.

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